Geophysical Research Abstracts, Vol. 7, 08232, 2005
SRef-ID: 1607-7962/gra/EGU05-A-08232

The composite tectonic-metamorphic and magmatic evolution of the Erro-Tobbio peridotite (Voltri Massif, Liguria Alps, Italy) during exhumation in the slow-spreading extension of the Europe-Adria continental lithosphere

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Results of recent structural, petrological and geochemical studies of the Erro-Tobbio (ET) ophiolitic peridotite (Voltri Massif – Liguria, Italy) (Piccardo et al., 2004a, 2004b) allow to get new insights in the composite evolution of a sector of mantle lithosphere of the Europe-Adria system from its pre-Permian residence in the sub-continental lithosphere to its emplacement at the sea-floor along the paleo-European passive margin of the Jurassic Ligurian Tethys oceanic basin.

Lithospheric mantle protoliths are sporadically preserved within the massif: they are represented by moderately depleted lherzolites, showing complete equilibration under spinel-facies conditions and preserving relatively high Na-Al cpx and subsolidus microtextures (i.e. sp+opx intergrowths) which suggest that a garnet-bearing precursor was accreted to the lithosphere and completely annealed at spinel-facies conditions (T below 1100˚C; P below 2.5 GPa). These spinel-facies protoliths were affected by extensional deformation giving rise to km-scale shear zones represented by spinel-facies tectonites and mylonites, which locally make transition to plagioclase-bearing mylonites (Vissers et al., 1991; Hoogerduijn Strating et al., 1993). The plagioclase-facies assemblage of these mylonites has yielded Permian Sm/Nd ages (Rampone et al., 2005); this fact suggests that continental extension in this sector of the Pangea supercontinent was already active since the Permian.

In the field, spinel tectonite-mylonites are replaced by large areas of completely recovered coarse granular spinel peridotites and plagioclase-rich peridotites. Spinel peridotites show microtextural and compositional features (i.e. pyroxene dissolution and olivine precipitation) which indicate a reactive origin, due to interaction with reactively percolating, pyroxene-undersaturated melts (Piccardo et al., 2004a; Rampone ey al., 2004). Plagioclase-rich peridotites show microtextural and compositional characteristics (i.e. olivine dissolution and orthopyroxene+plagioclase precipitation, interstitial crystallization of mm-size plagioclase-rich gabbro-noritic veins and pods) which indicate impregnation and refertilization by melt/peridotite interaction and the interstitial crystallization of variably pyroxene(-silica)-saturated percolating melts (Piccardo et al., 2004a, 2004b).

Spinel tectonite-mylonites and coarse granular spinel and plagioclase peridotites are cut by channels of coarse granular spinel dunites, replacive in origin, which are sporadically associated with cm-size gabbroic dikelets. Geochemical modelling indicates that the melts, which percolated and impregnated the ET peridotites and crystallized in the gabbroic dikelets associated with the replacive dunites, had a strongly LREE depleted signature and MORB affinity (Piccardo et al., 2004a), and can have been formed as depleted melt increments after fractional melting of an asthenospheric mantle source.

All these features show that continental rifting and thinning caused the passive upwelling of the asthenosphere which underwent partial melting under decompression. The produced melt fractions migrated upward by diffuse and focused porous flow into the extending lithospheric mantle. Trace element – based geothermometric data indicate that the former, relatively cold mantle lithosphere was significantly heated by asthenosphere upwelling and melt percolation (up to 1250˚C), close to solidus conditions. Abundance of reactive spinel peridotites and impregnated plagioclase peridotites suggest that asthenosphere/lithosphere interaction by melt percolation caused the thermochemical erosion (i.e heating and refertilization) of large sectors of the lithospheric mantle at relatively deep lithospheric levels, most probably around 1 GPa (i.e. transition from spinel- to plagioclase-facies conditions) (Piccardo et al., 2004). We emphasize that thermal softening of the mantle lithosphere can reduce the overall strenght of the extending lithosphere by 50% or more (depending on initial conditions), and could therefore be an important factor in the dynamics of the extensional system during transition from passive lithosphere stretching to active oceanic rifting (Ranalli et al., 2004).

A subsequent composite deformation-recrystallization evolution occurred under plagioclase- and amphibole-facies conditions, indicating that the ET peridotites underwent progressive cooling following an exhumation trajectory toward shallow levels. At moderate pressure conditions (about 0.3-0.5 GPa), they were intruded by variably evolved, MORB-type aggregated magmas which gave rise to mafic-ultramafic cumulate pods and gabbroic dikes (e.g. Borghini et al, 2005): preliminar Sm/Nd isotope investigations have provided an Early Jurassic age of intrusion.

The above composite evolution occurred prior to the continental breakup and the complete opening of the Late Jurassic Ligurian Tethys, when other sections of lithospheric mantle (i.e. Internal Ligurides and Corsica) reached shallow levels, were intruded by Late Jurassic gabbroic bodies and became associated with Late Jurassic basaltic volcanites and radiolarian cherts, the first oceanic sediments in the Ligurian Tethys. The Erro-Tobbio peridotite can thus be interpreted as a section of subcontinental lithospheric mantle which was first involved in slow-spreading extensional processes affecting the continental lithosphere of the Pangea supercontinent since the Permian and leading to Permian extension and, later, in Jurassic continental breakup. Present structural and petrological knowledge suggests that the Erro-Tobbio peridotite reached shallow levels before the complete opening of the Jurassic Tethys and was thus located at the ocean-continent transition of the paleo-European passive margin.

Vissers R.L.M., Drury M.R., Hoogerduijn Strating E.H., van der Wal D. (1991) – Shear zones in the upper mantle: a case study in an Alpine lherzolite massif. Geology, 19, 990-003.

Hoogerduijn Strating E.H., Rampone E., Piccardo G.B., Drury M.R., Vissers R.L.M. (1993) – Subsolidus emplacement of mantle peridotites during incipient oceanic rifting and opening of the Mesozoic Tethys (Voltri Massif, NW Italy). Journal of Petrology., 34, 901-927.

PiccardoG.B., MüntenerO., Zanetti A., PettkeT. (2004a) - Ophiolitic peridotites of the Alpine-Apennine system: mantle processes and geodynamic relevance. International Geology Review, 46, 1119-1159.

Piccardo G.B., Müntener O., Zanetti A. (2004b) – Alpine-Apennine ophiolitic peridotites: new concepts on their composition and evolution. Ofioliti, 29 (1), 63-74.

Rampone E., Romairone A. & Hofmann A.W. (2004) – Contrasting bulk and mineral chemistry in depleted mantle peridotites: evidence for reactive porous flow. Earth and Planetary Science Letters, 218, 491-506.

Ranalli G., Corona-Chávez P., Piccardo G.B., Poggi E. (2004) - Softening of the subcontinental lithospheric mantle by impregnation of asthenospheric melts: a possible factor in the transition continental extension/oceanic spreading? Earth Science Meeting of the SGF and GV, Strasbourg (France), Abstract Number RSTGV-A-00249.

Rampone E., Romairone A., Abouchami W., & Hofmann A.W. (2005) – Chronology, petrology and isotope geochemistry of the Erro-Tobbio peridotites (Ligurian Alps, Italy): records of Late Palaeozoic lithospheric extension. Journal of Petrology, in press.

Borghini G., Crispini L., De Ferrari R., & Rampone E. (2005) – Origin and emplacement of ultramafic and gabbroic intrusions in the Erro-Tobbio mantle peridotite (Ligurian Als, Italy). Lithos, submitted.